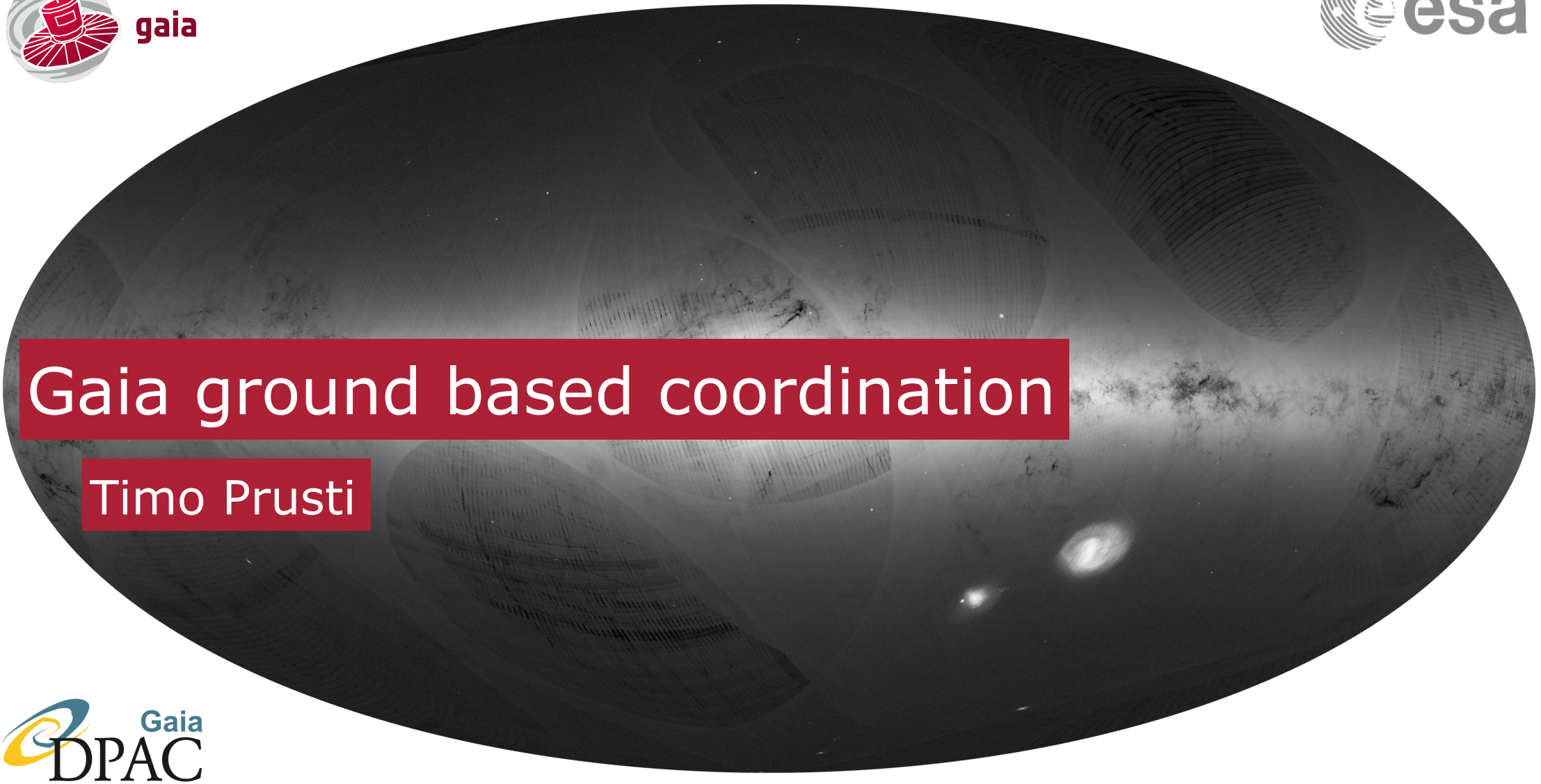


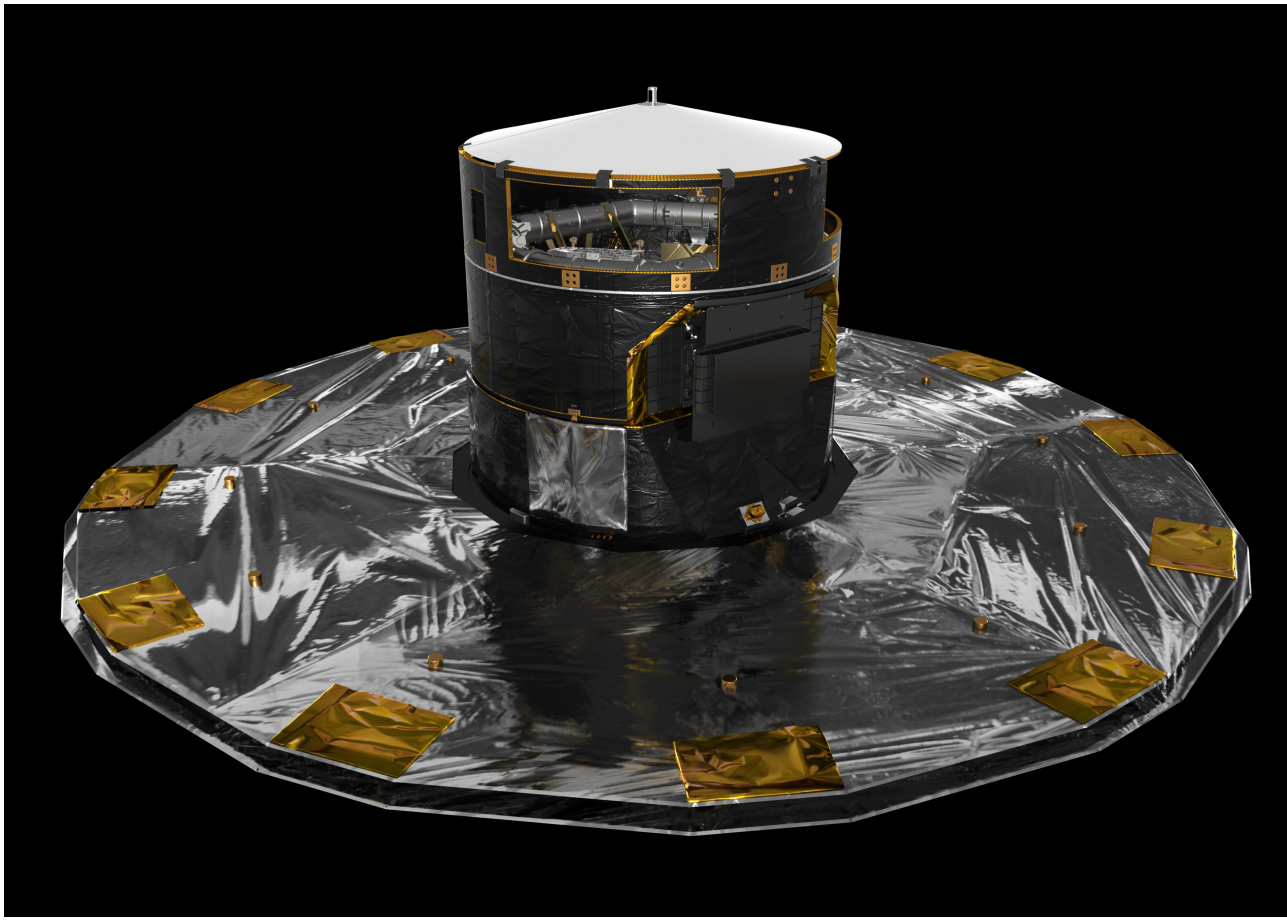
Gaia ground based coordination

Timo Prusti

Gaia DPAC
Data Processing & Analysis Consortium

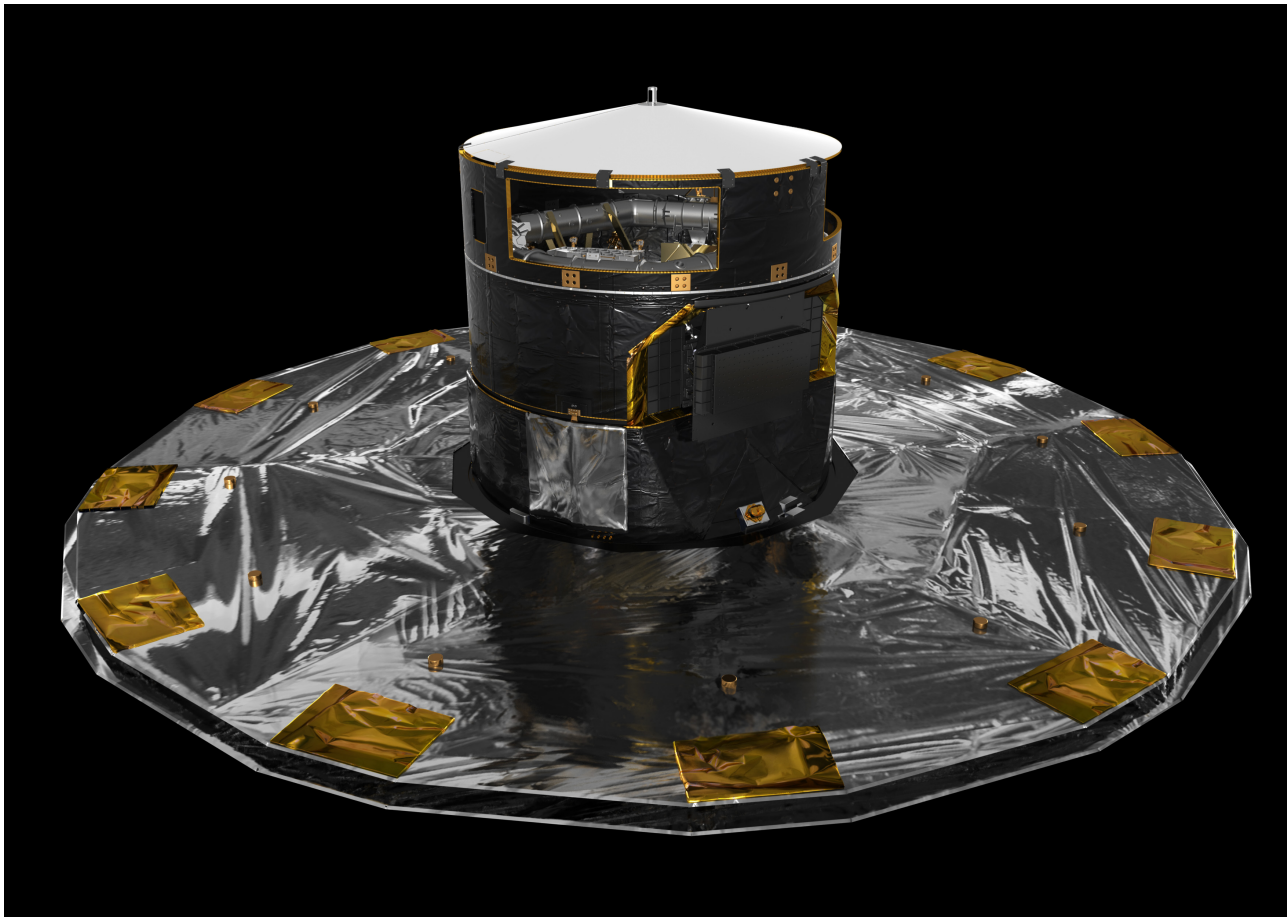
Contents

- Ground based calibration programme
- Ground based tracking programme
- Ground based follow-up



Contents

- **Ground based calibration programme**
- Ground based tracking programme
- Ground based follow-up



Ground based calibration programme

- Gaia calibration needs were coordinated
- Ground Based Observations for Gaia (GBOG)
  - Coordination within the DPAC:
    - identify overlaps among needs, targets, facilities
    - avoid duplicate efforts, optimise the observing time requests
    - construct a long-term observation plan
  - Communication outside DPAC:
    - present well organised and motivated data acquisition plan to the observatories and time allocation committees (TACs faced a growing number of proposals claiming to be important for Gaia …)

GBOG

- Data processing calibrations
  - Photometry (G, BP/RP) flux calibration
  - Radial velocity zero point
- Training datasets
  - Stellar parametrisation
  - Asteroid taxonomy
- Calibration fields for the commissioning
  - Astrometry, photometry, spectroscopy at the Ecliptic Poles
- Reference frame
  - Alignment of optical / radio, VLBI
  - QSO catalogue, morphology, optical monitoring

SpectroPhotometric Standard Stars (SPSS)

- Calibrate all Gaia BP/RP spectra and G-band photometry
  - ~200 of SPSS flux tables, Vega calibrated, accuracy few percent, strict quality constraints
  - Primary SPSS calibrated on the three CALSPEC Pillars (Bohlin, 2007)
  - Secondary SPSS (Gaia SPSS grid) calibrated on Primary SPSS
- ~480 nights at 6 telescopes started in 2006, end summer 2015
- Four campaigns:
  - Spectroscopy
  - Absolute photometry
  - Short term (2 h) Constancy monitoring
  - Long term (3 yrs) Constancy monitoring

SPSS observations

- Observing facilities:
  - CAFOS @ 2.2 m Calar Alto telescope, absolute photometry and spectroscopy, C. Jordi
  - DOLoRes @ TNG La Palma telescope, absolute photometry and spectroscopy, E. Pancino
  - EFOSC2@ NTT La Silla telescope, absolute photometry and spectroscopy, E. Pancino
  - LaRuca @ 1.5 m San Pedro Martir telescope, relative photometry, variability , F. Figueras
  - ROSS @ REM La Silla robotic telescope, relative photometry, variability , E. Pancino
  - BFOSC @ Loiano Cassini telescope, relative photometry, variability , G. Altavilla

Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY

Mon. Not. R. Astron. Soc. **426,** 1767–1781 (2012) doi:10.1111/j.1365-2966.2012.21766.x

The *Gaia* spectrophotometric standard stars survey – I. Preliminary results★

E. Pancino,[1]† G. Altavilla,[1] S. Marinoni,[1,2,3] G. Cocozza,[1] J. M. Carrasco,[4] M. Bellazzini,[1] A. Bragaglia,[1] L. Federici,[1] E. Rossetti,[5] C. Cacciari,[1] L. Balaguer Núñez,[4] A. Castro,[6] F. Figueras,[4] F. Fusi Pecci,[1] S. Galleti,[1] M. Gebran,[7] C. Jordi,[4] C. Lardo,[5] E. Masana,[4] M. Monguió,[4] P. Montegriffo,[1] S. Ragaini,[1] W. Schuster,[6] S. Trager,[8] F. Vilardell[9] and H. Voss[4]

[1]*Osservatorio Astronomico di Bologna, INAF, Via C. Ranzani, 1, I-40127 Bologna, Italy*
[2]*Osservatorio Astronomico di Roma, INAF, Via di Frascati, 33, I-00040 Monte Porzio Catone, Italy*
[3]*ASI Science Data Center, c/o ESA-ESRIN, Via Galileo Galilei, s/n, I-00044 Frascati, Italy*
[4]*Departament d'Astronomia i Meteorologia, Institut del Ciències del Cosmos (ICC), Universitat de Barcelona (IEEC-UB), c/ Martí i Franquès, 1, 08028 Barcelona, Spain*
[5]*Dipartimento di Astronomia, Università di Bologna, Via C. Ranzani, 1, I-40127 Bologna, Italy*
[6]*Observatorio Astronómico Nacional, Universidad Nacional Autónoma de México, Apartado Postal 877, C. P. 22800 Ensenada, BC, Mexico*
[7]*Department of Physics and Astronomy, Notre Dame University Louiaze, PO Box 72, Zouk Mikael, Zouk Mosbeh, Lebanon*
[8]*Kapteyn Institute, University of Groningen, PO Box 800, 9700 AV Groningen, the Netherlands*
[9]*Institut d'Estudis Espacial de Catalunya, Edifici Nexus, c/ Capitá, 2-4, desp. 201, E-08034 Barcelona, Spain*

Accepted 2012 July 20. Received 2012 July 20; in original form 2012 June 22

ABSTRACT

We describe two ground-based observing campaigns aimed at building a grid of approximately 200 spectrophotometric standard stars (SPSS), with an internal $\simeq$1 per cent precision and tied to Vega within $\simeq$3 per cent, for the absolute flux calibration of data gathered by *Gaia*, the European Space Agency (ESA) astrometric mission. The criteria for the selection and a list of candidates are presented, together with a description of the survey strategy and the adopted data analysis methods. We also discuss a short list of notable rejected SPSS candidates and difficult cases, based on identification problems, literature discordant data, visual companions and variability. In fact, all candidates are also monitored for constancy (within $\pm$5 mmag, approximately). In particular, we report on a CALSPEC standard, 1740346, that we found to be a δ Scuti variable during our short-term monitoring (1–2 h) campaign.

Key words: techniques: photometric – techniques: spectroscopic – catalogues – stars: variables: δ Scuti.

Radial velocities

- Radial Velocity Spectrometer zero point based on primary standard stars

- Bright FGK single stars (V < 11)
  - initial list of 1420 stars (Crifo et al. 2010, Soubiran et al. 2013)
  - 1100 new standards (article in preparation for Gaia DR2)
  - new observations (SOPHIE, NARVAL, CORALIE) + archives (ELODIE – HARPS)

Radial velocity standard stars

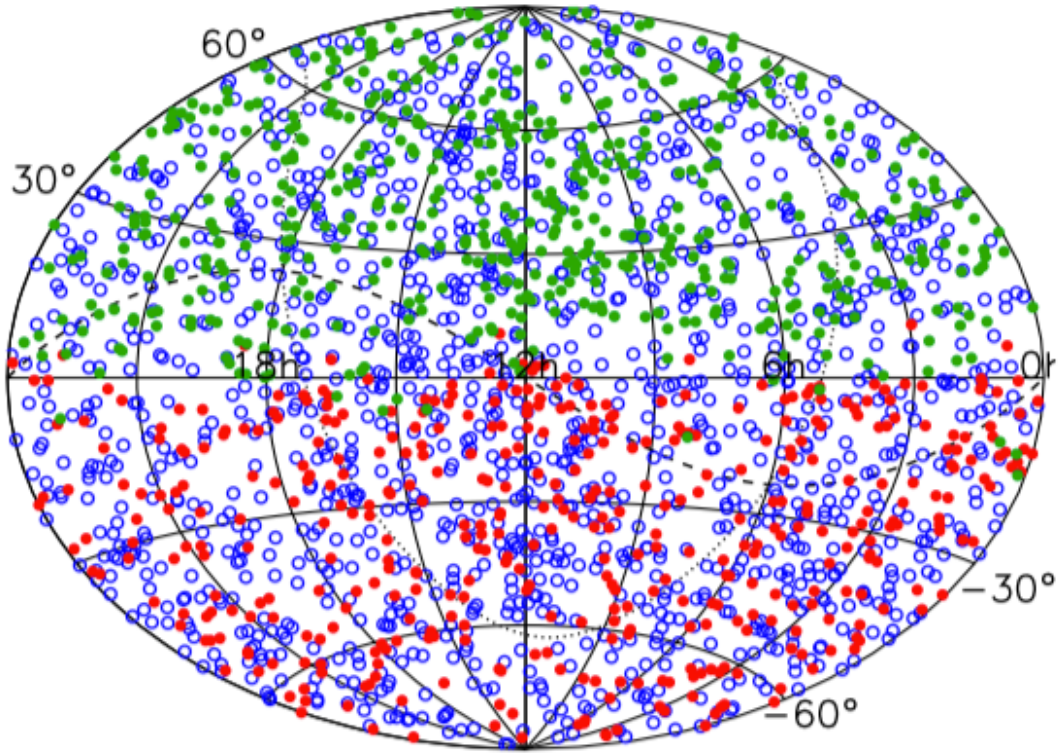


FIGURE 2: Distribution of the 426 new primary RV-STD candidates (red dots) with the original sample of 1292 ones (Crifo1, blue open circles) and the 525 additional ones (Soubiran1, green dots) on the celestial sphere in equatorial coordinates. A dashed line indicates the projection of the Ecliptic plane, a dotted line that of the Galactic plane.

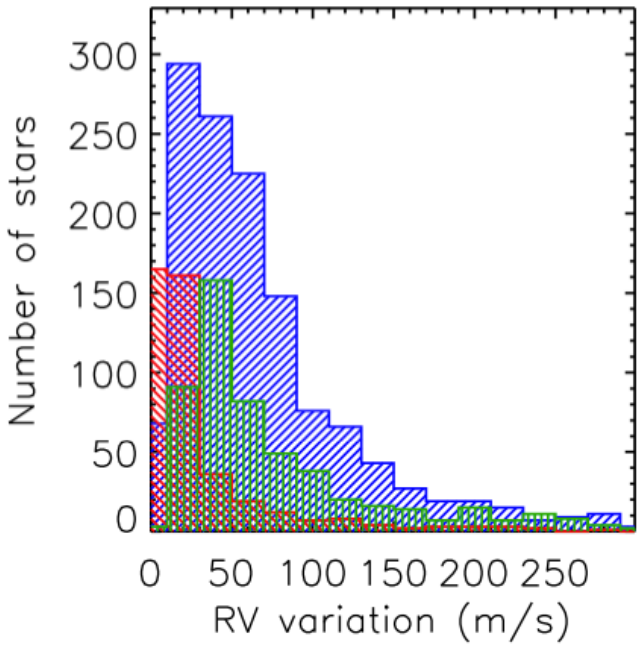
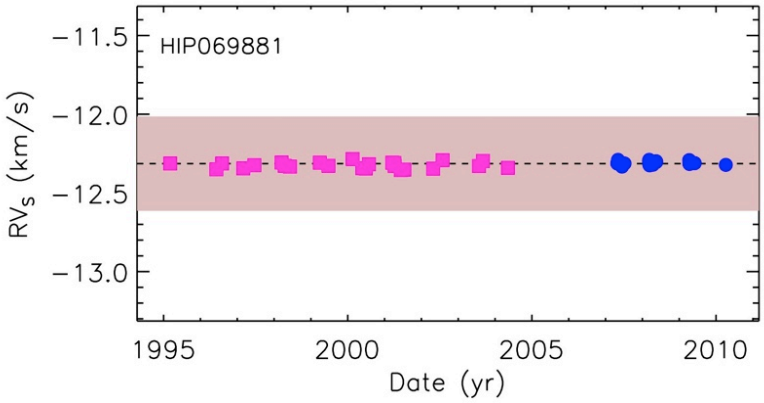


FIGURE 4: Distribution of RV variations of the new (red) and previous (blue and green) primary RV-STD candidates.



Observations

A&A 552, A64 (2013)
DOI: 10.1051/0004-6361/201220927

Astronomy & Astrophysics

The catalogue of radial velocity standard stars for *Gaia*

I. Pre-launch release⋆,⋆⋆

C. Soubiran[1], G. Jasniewicz[2], L. Chemin[1], F. Crifo[3], S. Udry[4], D. Hestroffer[5], and D. Katz[3]

[1] LAB UMR 5804, Univ. Bordeaux – CNRS, 33270 Floirac, France
e-mail: soubiran@obs.u-bordeaux1.fr
[2] LUPM UMR 5299 CNRS/UM2, Université Montpellier II, CC 72, 34095 Montpellier Cedex 05, France
[3] GEPI, Observatoire de Paris, CNRS, Université Paris Diderot, 5 place Jules Janssen, 92190 Meudon, France
[4] Observatoire de Genève, Université de Genève, 51 Ch. des Maillettes, 1290 Sauverny, Switzerland
[5] IMCCE, Observatoire de Paris, UPMC, CNRS UMR 8028, 77 Av. Denfert-Rochereau, 75014 Paris, France

Received 14 December 2012 / Accepted 6 February 2013

ABSTRACT

The Radial Velocity Spectrograph (RVS) on board *Gaia* needs to be calibrated using stable reference stars known in advance. The catalogue presented here was built for that purpose. It includes 1420 radial velocity standard star candidates selected on strict criteria to fulfil the *Gaia*-RVS requirements. A large programme of ground-based observations has been underway since 2006 to monitor these stars and verify their stability, which has to be better than 300 m s^{-1} over several years. The observations were done on the echelle spectrographs ELODIE and SOPHIE on the 1.93-m telescope at Observatoire de Haute-Provence (OHP), NARVAL on the Télescope *Bernard Lyot* at Observatoire du Pic du Midi and CORALIE on the *Euler*-Swiss Telescope at La Silla. Data from the OHP and Geneva Observatory archives have also been retrieved as have HARPS spectra from the ESO archive. We provide a mean radial velocity in the SOPHIE scale for each star, derived from the combination of velocities measured with those instruments, after having carefully estimated their differences in zero points. In total, 10214 radial velocity measurements have been obtained for the 1420 stars. With a mean time baseline of 6.35 years, 92.9% of the candidates fulfil a target stability criterion of 300 m s^{-1}. Three hundred forty-three stars are found to be constant at the level of 100 m s^{-1} over 10 years. Comparisons with earlier catalogues show excellent agreement for FGK stars, with zero-point differences lower than 100 m s^{-1} and a remarkably low rms scatter of 33 m s^{-1} in one case, suggesting that the precision of the catalogue presented here is better than this value. This catalogue will likely be useful for other large-scale spectroscopic surveys, such as APOGEE, *Gaia*-ESO, HERMES, and LAMOST.

Key words. catalogs – stars: kinematics and dynamics

A&A 597, A10 (2017)
DOI: 10.1051/0004-6361/201629549

Astronomy & Astrophysics

A test field for *Gaia*

Radial velocity catalogue of stars in the South Ecliptic Pole⋆,⋆⋆,⋆⋆⋆,⋆⋆⋆⋆

Y. Frémat[1], M. Altmann[2,3], E. Pancino[4,5], C. Soubiran[6], P. Jofré[6,7,8], Y. Damerdji[9,10], U. Heiter[11], F. Royer[12], G. Seabroke[13], R. Sordo[14], S. Blanco-Cuaresma[15,6], G. Jasniewicz[16], C. Martayan[17], F. Thévenin[18], A. Vallenari[14], R. Blomme[1], M. David[19], E. Gosset[10], D. Katz[12], Y. Viala[12], S. Boudreault[13,20], T. Cantat-Gaudin[14], A. Lobel[1], K. Meisenheimer[21], T. Nordlander[11], G. Raskin[22], P. Royer[22], and J. Zorec[23]

(Affiliations can be found after the references)

Received 18 August 2016 / Accepted 22 September 2016

ABSTRACT

Context. *Gaia* is a space mission that is currently measuring the five astrometric parameters, as well as spectrophotometry of at least 1 billion stars to $G = 20.7$ mag with unprecedented precision. The sixth parameter in phase space (i.e., radial velocity) is also measured thanks to medium-resolution spectroscopy that is being obtained for the 150 million brightest stars. During the commissioning phase, two fields, one around each ecliptic pole, have been repeatedly observed to assess and to improve the overall satellite performances, as well as the associated reduction and analysis software. A ground-based photometric and spectroscopic survey was therefore initiated in 2007, and is still running to gather as much information as possible about the stars in these fields. This work is of particular interest to the validation of the radial velocity spectrometer outputs.
Aims. The paper presents the radial velocity measurements performed for the Southern targets in the 12−17 R magnitude range on high- to mid-resolution spectra obtained with the GIRAFFE and UVES spectrographs.
Methods. Comparison of the South Ecliptic Pole (SEP) GIRAFFE data to spectroscopic templates observed with the HERMES (*Mercator* in La Palma, Spain) spectrograph enabled a first coarse characterisation of the 747 SEP targets. Radial velocities were then obtained by comparing the results of three different methods.
Results. In this paper, we present an initial overview of the targets to be found in the 1 sq. deg SEP region that was observed repeatedly by *Gaia* ever since its commissioning. In our representative sample, we identified one galaxy, six LMC S-stars, nine candidate chromospherically active stars, and confirmed the status of 18 LMC Carbon stars. A careful study of the 3471 epoch radial velocity measurements led us to identify 145 RV constant stars with radial velocities varying by less than 1 km s^{-1}. Seventy-eight stars show significant RV scatter, while nine stars show a composite spectrum. As expected, the distribution of the RVs exhibits two main peaks that correspond to Galactic and LMC stars. By combining [Fe/H] and $\log g$ estimates, and RV determinations, we identified 203 members of the LMC, while 51 more stars are candidate members.
Conclusions. This is the first systematic spectroscopic characterisation of faint stars located in the SEP field. During the coming years, we plan to continue our survey and gather additional high- and mid-resolution data to better constrain our knowledge on key reference targets for *Gaia*.

Key words. stars: kinematics and dynamics

Stellar parametrisation

- Benchmark and reference stars for the calibration of Gaia Photometry and Spectroscopy
- Large compilations of Astrophysical Parameters

TABLE 2: Summary of the different catalogue contributions in the compilation of 1 930 105 stars. Teff, logg and [Fe/H] were assigned according to the priority order indicated in the first column.

Priority	Catalogue	N_{Teff}	N_{logg}	$N_{[Fe/H]}$
1	Benchmark Stars	33	33	33
2	GBOG AP	1 139	1 139	1 082
3	Seismic logg	517	517	0
4	PASTEL + OBA	19 187	8 796	7 946
5	AMBRE	2 006	1 954	1 963
6	RAVE DR4	359 229	349 410	359 694
7	MILES	95	120	123
8	CFLIB	243	304	327
9	OBA *uvby*	11 354	10 343	0
10	KIC	161 342	161 348	161 775
11	GCS	6 787	10 502	12 743
12	Robinson et al.	527	561	557
13	McDonald et al.	77 977	0	0
14	Ammons et al.	1 290 815	0	0

- Faint stars at South Ecliptic Pole

Benchmark literature

- Value beyond Gaia already now as results are published

Gaia FGK benchmark stars: a bridge between spectroscopic surveys

Paula Jofré[1,2*], Ulrike Heiter[3] and Sven Buder[4]

[1] *Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK*
[2] *Núcleo de Astronomía, Universidad Diego Portales, Ejército 441, Santiago, Chile.*
[3] *Department of Physics and Astronomy, Uppsala University, Box 516, 75120 Uppsala, Sweden*
[4] *Max-Planck Institute for Astronomy, 69117, Heidelberg, Germany*

Received — ; accepted —

Abstract. The *Gaia* benchmark stars (GBS) are very bright stars of different late spectral types, luminosities and metallicities. They are well-known in the Galactic archaeology community because they are widely used to calibrate and validate the automatic pipelines delivering parameters of on-going and future spectroscopic surveys. The sample provides us with consistent fundamental parameters as well as a library of high resolution and high signal-to-noise spectra. This allows the community to study details of high resolution spectroscopy and to compare results between different survey pipelines, putting the GBS at the heart of this community. Here we discuss some results arising from using the GBS as main data source for spectral analyses.

Keywords : stellar atmospheres – Gaia – spectroscopic surveys

Query Results from the ADS Database

Retrieved 9 abstracts, starting with number 1. Total number selected: 9.

Jofre, Paula, Heiter, Ulrike,
& Buder, Sven Gaia FGK benchmark stars: a bridge between spectroscopic surveys
2017arXiv170909366J

Jofré, P., Heiter, U., Worley, C. C., Blanco-Cuaresma, S., Soubiran, C.,
Masseron, T., Hawkins, K., Adibekyan, V., Buder, S., Casamiquela, L.,
Gilmore, G., Hourihane, A.,
& Tabernero, H. Gaia FGK benchmark stars: opening the black box of stellar element abundance
determination 2017A&A...601A..38J

Jofré, P. Gaia benchmark stars and their twins in the Gaia-ESO Survey
2016AN....337..859J

Hawkins, K., Jofré, P., Heiter, U., Soubiran, C., Blanco-Cuaresma, S.,
Casagrande, L., Gilmore, G., Lind, K., Magrini, L., Masseron, T., Pancino,
E., Randich, S.,
& Worley, C. C. Gaia FGK benchmark stars: new candidates at low metallicities
2016A&A...592A..70H

Jofré, P., Heiter, U., Soubiran, C., Blanco-Cuaresma, S., Masseron, T.,
Nordlander, T., Chemin, L., Worley, C. C., Van Eck, S., Hourihane, A.,
Gilmore, G., Adibekyan, V., Bergemann, M., Cantat-Gaudin, T., Delgado-Mena,
E., González Hernández, J. I., Guiglion, G., Lardo, C., de Laverny, P.,
Lind, K., Magrini, L., Mikolaitis, S., Montes, D., Pancino, E.,
Recio-Blanco, A., Sordo, R., Sousa, S., Tabernero, H. M.,
& Vallenari, A. Gaia FGK benchmark stars: abundances of α and iron-peak elements
2015A&A...582A..81J

Heiter, U., Jofré, P., Gustafsson, B., Korn, A. J., Soubiran, C.,
& Thévenin, F. Gaia FGK benchmark stars: Effective temperatures and surface gravities
2015A&A...582A..49H

Creevey, O. L., Thévenin, F., Berio, P., Heiter, U., von Braun, K.,
Mourard, D., Bigot, L., Boyajian, T. S., Kervella, P., Morel, P., Pichon,
B., Chiavassa, A., Nardetto, N., Perraut, K., Meilland, A., Mc Alister, H.
A., ten Brummelaar, T. A., Farrington, C., Sturmann, J., Sturmann, L.,
& Turner, N. Benchmark stars for Gaia Fundamental properties of the Population II star HD
140283 from interferometric, spectroscopic, and photometric data 2015A&A...575A..26C

Blanco-Cuaresma, S., Soubiran, C., Jofré, P.,
& Heiter, U. The Gaia FGK benchmark stars. High resolution spectral library
2014A&A...566A..98B

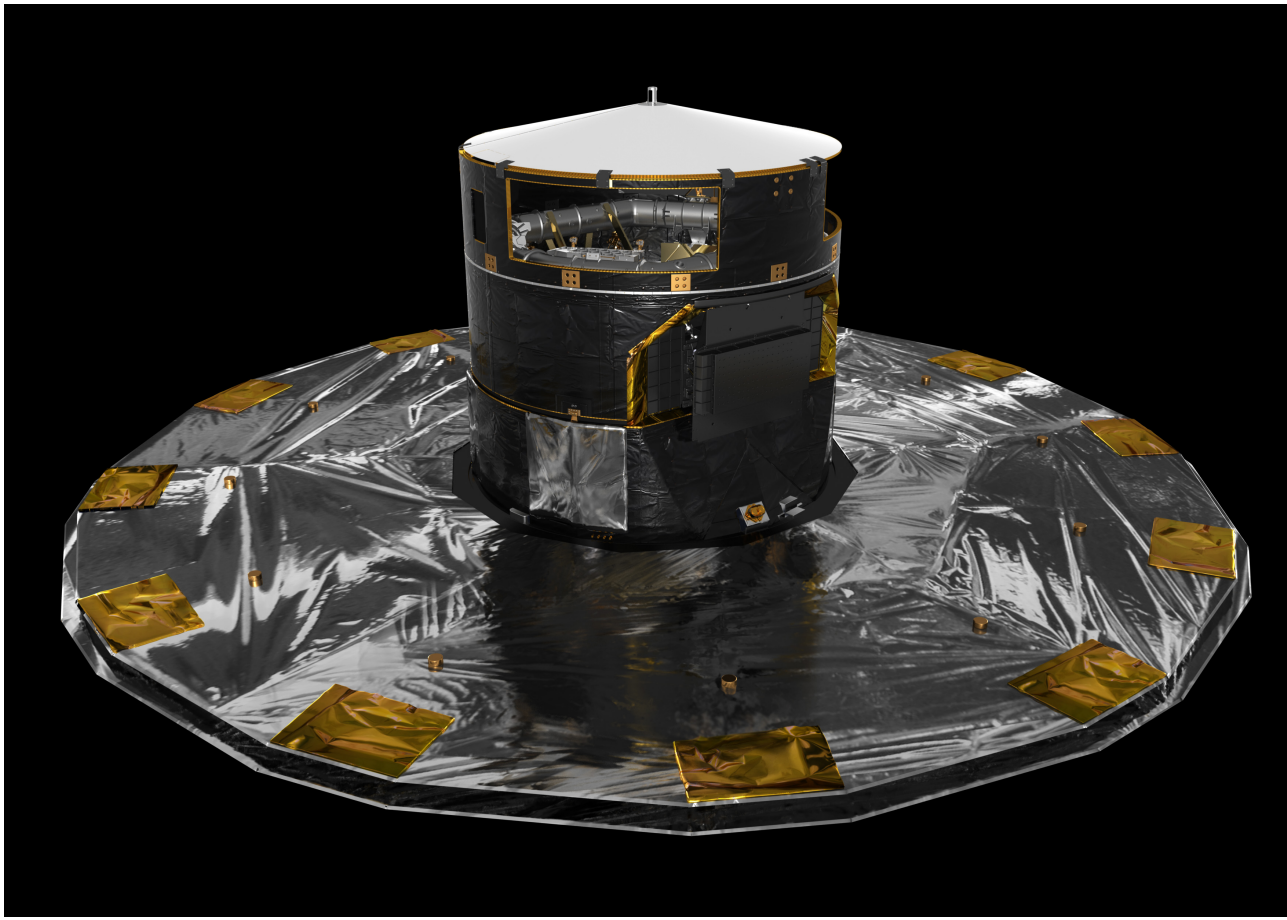
Jofré, P., Heiter, U., Soubiran, C., Blanco-Cuaresma, S., Worley, C. C.,
Pancino, E., Cantat-Gaudin, T., Magrini, L., Bergemann, M., González
Hernández, J. I., Hill, V., Lardo, C., de Laverny, P., Lind, K., Masseron,
T., Montes, D., Mucciarelli, A., Nordlander, T., Recio Blanco, A., Sobeck,
J., Sordo, R., Sousa, S. G., Tabernero, H., Vallenari, A.,
& Van Eck, S. Gaia FGK benchmark stars: Metallicity 2014A&A...564A.133J

Further GBOG projects

- In addition to use of surveys 6 observing programs for variability:
  - photometry of selected Cepheids (L. Szabados)
  - spectra of LPVs (Miras, Ir variables) in the spectral range of RVS at a resolution around 10000 (P. Koubski & T. Lebzelter)
  - photometry of short period variables based on Eddington fast–read CCDs (Geneva team: L. Eyer, N. Mowlavi, M. Varadi)
  - photometry of Be stars (P. Koubski)
  - time series photometry of the NEP (I. Kolka)
  - time series photometry of the SEP (G. Clementini)
- Spectroscopic observations of asteroids as a support to the Gaia space mission
  - PI: P. Tanga, Dolores@Telescopio Nationale Galileo
- QSO morphology observed/monitored for reference frame purposes
  - PI: G. Bourda, VLBI network (EVN+VLBA)
  - PI: A. Andrei, F. Taris CFHT-LS, SOAR-OI, ESO-MPIAT2.2/WFI, Tarot, OHP-T120
- ICRF3 in the making for IAU GA 2018 approval
  - Gaia reference frame oriented to prototype ICRF3 and joint work on-going to match Gaia reference frame and ICRF3

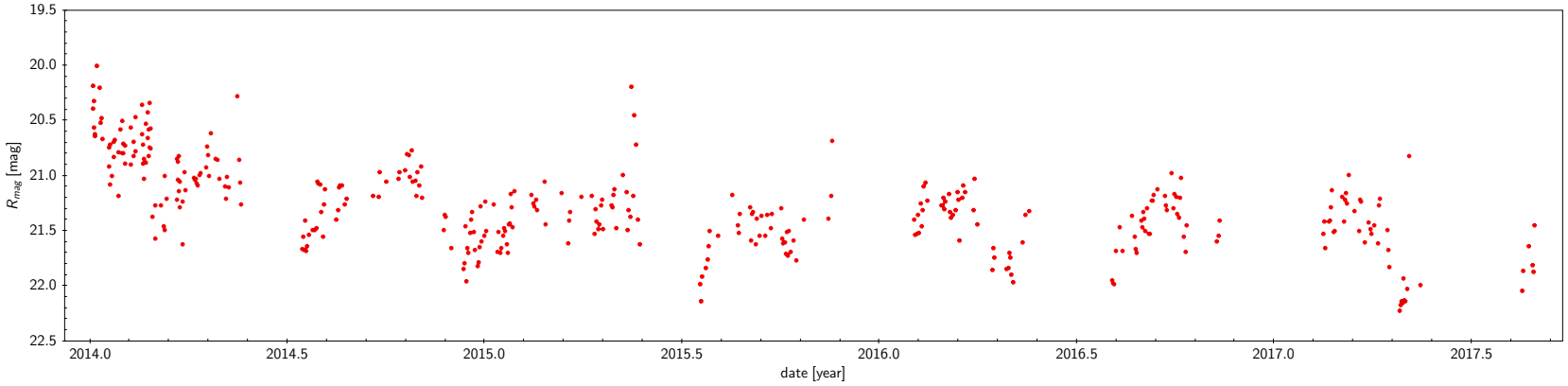
Contents

- Ground based calibration programme
- **Ground based tracking programme**
- Ground based follow-up



Ground based tracking programme

- For astrometry spacecraft orbit and attitude needs to be known very precisely
  - Attitude: from AGIS
  - Orbit: from Mission Operation Centre
    - Gaia accuracy requirement (150 m position and 2.5 mm/s velocity) not achievable with ranging and tracking methods only
    - Ground Based Optical Tracking (GBOT)



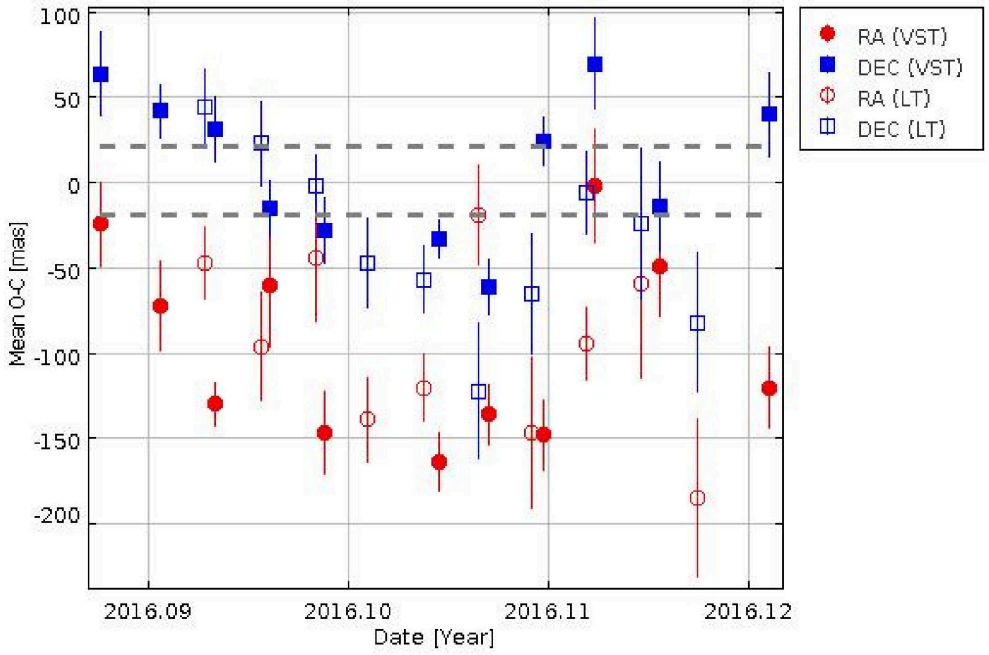
    - VST, LT and Las Cumbres needed for 20 mas precision

GBOT

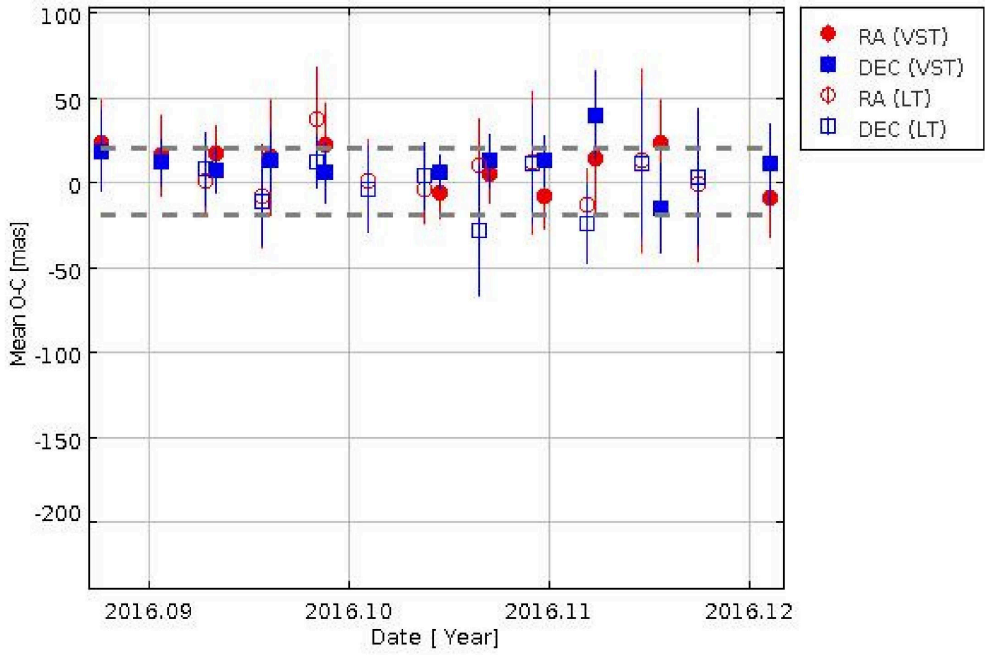
- GBOT Principal Coordinator:
  - Martin Altmann (ARI, ZAH Heidelberg, Germany)
- Members of "Data Storage and Processing Center of GBOT" at SyRTE (Observatoire de Paris, France):
  - Christophe Barache
  - Sebastien Bouquillon
  - Teddy Carlucci
  - Francois Taris
- Other members of the GBOT team:
  - Alexandre Andrei (Observatorio National/MCT & Observatorio do Valongo/UFRJ, Brazil)
  - Uli Bastian (ARI, ZAH Heidelberg, Germany)
  - Francois Mignard (OCA, Nice, France)
  - Luciano Nicastro (INAF, Bologna, Italy)
  - Ricky Smart (INAF, Torino, Italy)
  - Iain Steele (LJMU, Liverpool, UK)
  - Jon Marchant (LJMU, Liverpool, UK)
  - Paolo Tanga (OCA, Nice, France)
  - Tim Lister (LCOGT, Santa Barbara,USA)

GBOT accuracy

- No astrometric catalogue available to convert 20 mas precision to 20 mas accuracy
- GBOT had to wait for the Gaia catalogue



Reference catalogue: PPMXL



Reference catalogue: Gaia

- and now waiting for the Gaia DR2 for proper motions

New asteroids from GBOT

- GBOT data immediately public
- GBOT team extracts and publishes for follow-up new asteroid alerts
- http://gbot.obspm.fr/index.php?page=asteroids
- Typically 10 to 80 asteroids in VST field of view close to Gaia in a 20 min observation

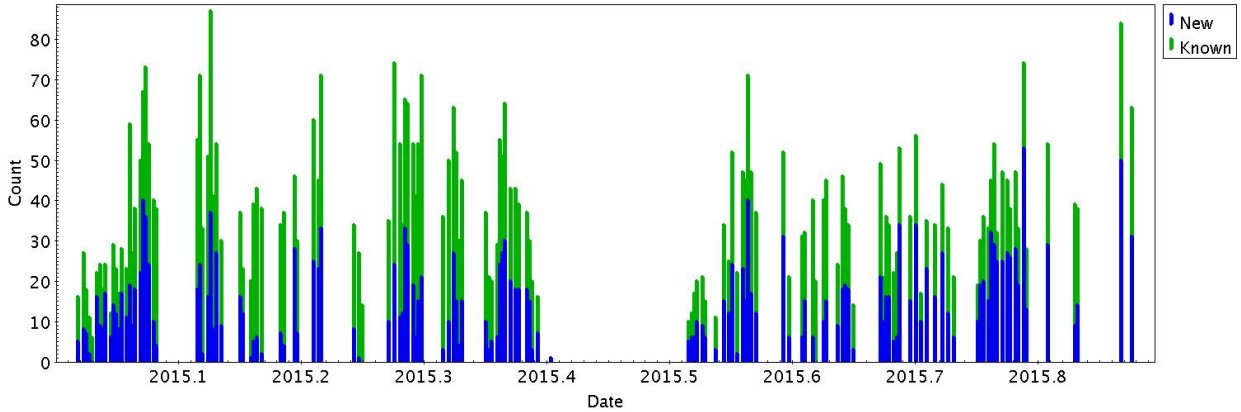
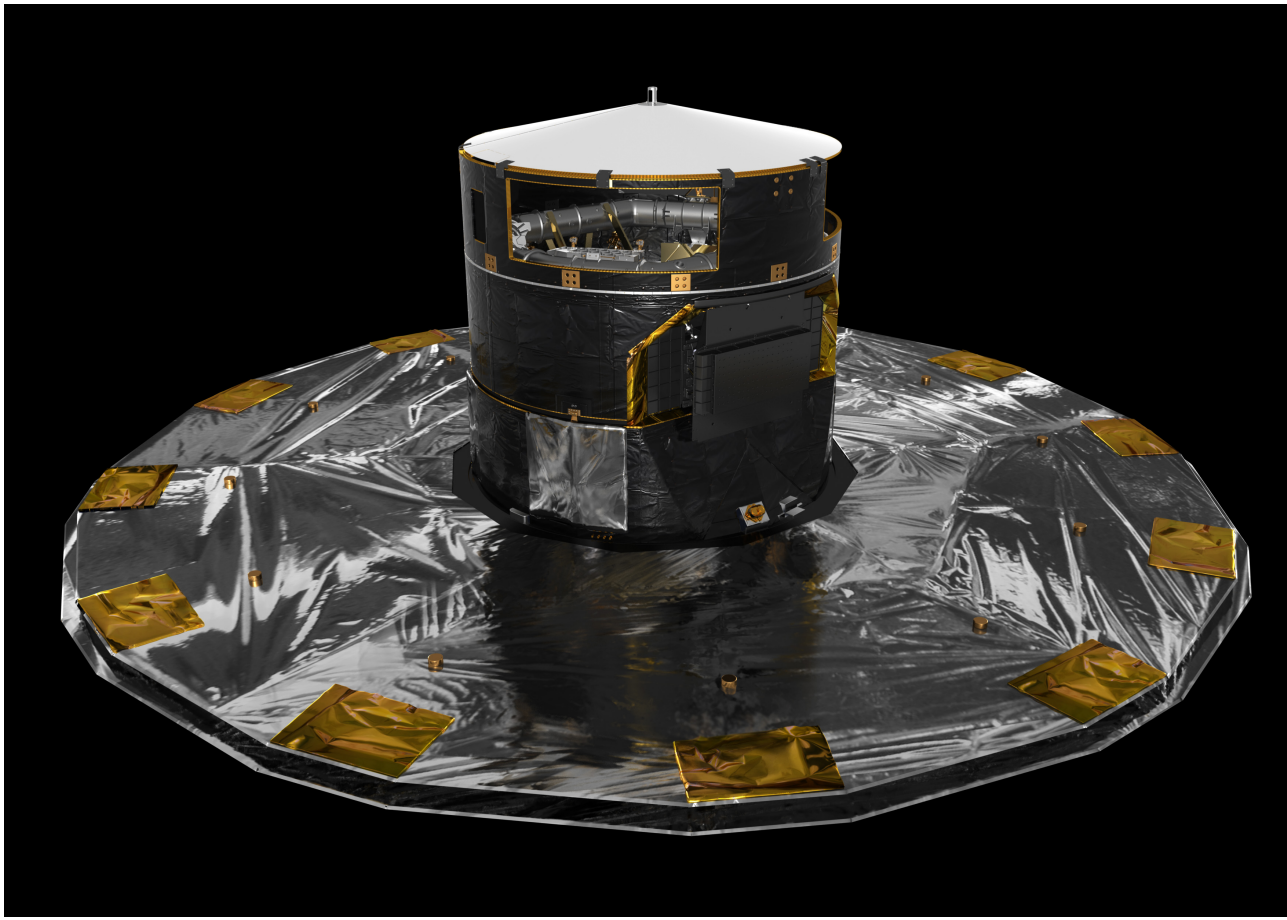


Fig. 2: *Number of asteroids found on every night of 2015. The blue parts of each bar show asteroids which are currently not previously in the MPC database, while the green parts those objects, which could be identified as previously observed.*

Contents

- Ground based calibration programme
- Ground based tracking programme
- **Ground based follow-up**



Ground based follow-up

- No proprietary rights for Gaia data
  - Follow-up in principle left for the community
- Gaia DR1 extensively combined with ground based data
  - Especially ground-based spectroscopic surveys (RAVE, LAMOST, …) exploited in combination with Gaia data

- Collaboration encouraged and stimulated especially in view of large projects
- The Gaia Research for European Astronomy Training (GREAT)
  - Forum to discuss science and projects related to Gaia
  - Separated from formal ESA and DPAC functional work
  - Open for everyone to join specific activities

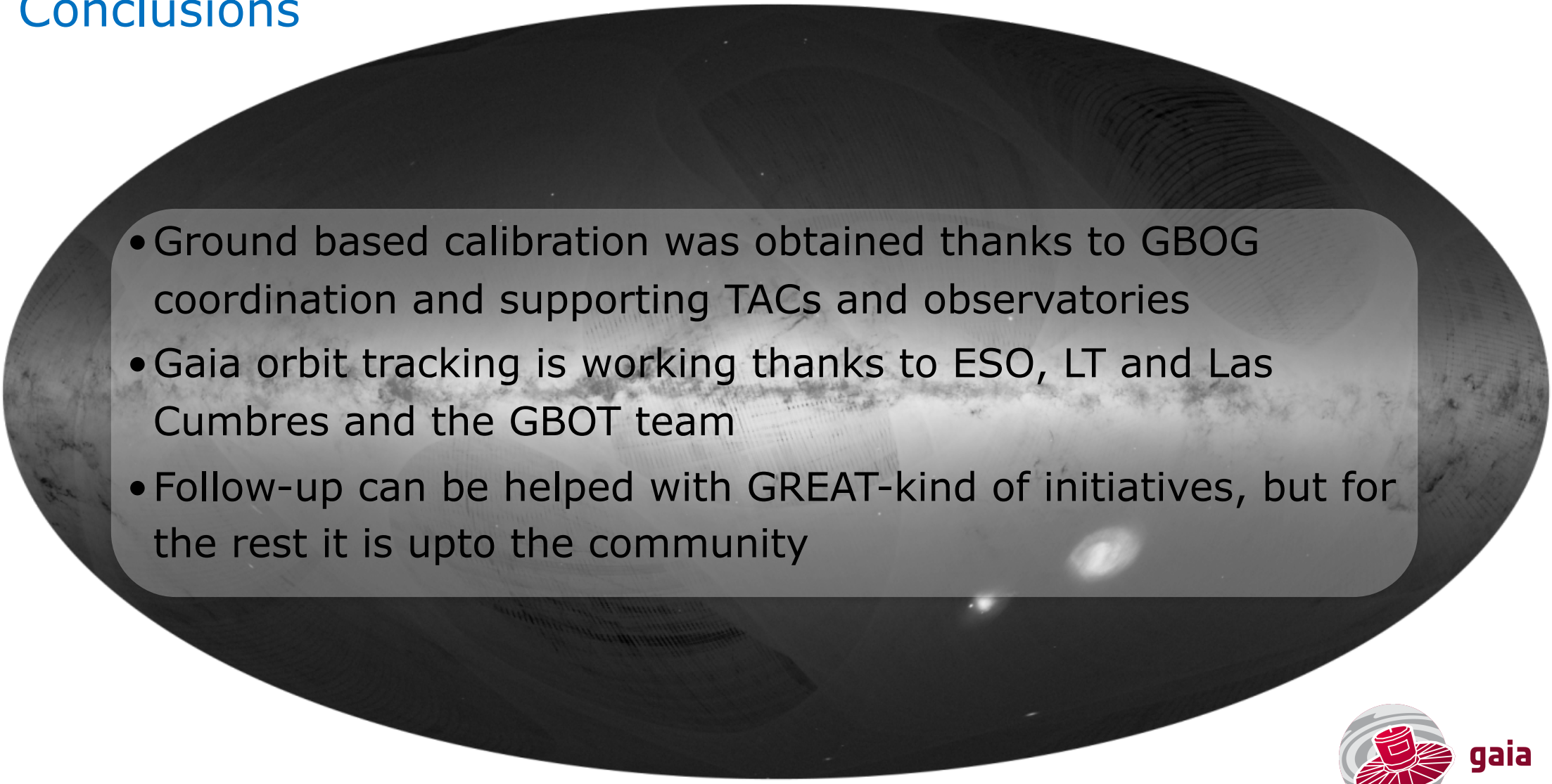
GREAT

- Various EU and ESF funded programmes
  - Meetings, conferences, visits, and PhD students
- Initial forum to discuss many ground based projects
  - WEAVE
  - 4MOST
  - Gaia-ESO survey
    - Anticipated follow-up, but observations will be completed before Gaia DR2

Gaia-ESO

- 340 nights on VLT using Giraffe and UVES observations (plus reanalysis of data in ESO archives) of Milky Way and Open Cluster stars
  - About 150,000 spectra of 100,000 stars
- Consortium of 450 members
- 65 refereed publications
- Public DR3 served from ESO (raw data always public)
- Matches well Gaia DR2

Conclusions



- Ground based calibration was obtained thanks to GBOG coordination and supporting TACs and observatories
- Gaia orbit tracking is working thanks to ESO, LT and Las Cumbres and the GBOT team
- Follow-up can be helped with GREAT-kind of initiatives, but for the rest it is upto the community

gaia